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laws, for pure induction is impossible. Rather, hypotheses should be so chosen that by their use in their ensemble mathematical deduction can draw consequences which represent with sufficient approximation the ensemble of experimental laws. The schematic representation, by mathematical symbols, of experimental laws is the purpose of physical theory. The hypotheses chosen and used are accordingly the result of a progressive evolution, and a repeated retouching is necessary. It may even be said that they are not chosen, but that they 'germinate' in the physicist because of his habits of thought in the traditions of the science.

The author closes the volume with a discussion as to the manner in which physics should be taught; he finds that in every exposition a compromise must be made between the exigencies of logic and the intellectual needs of the student.

In this review it has been impossible, because of the full and thoroughgoing presentation which the author makes, to do more than give an outline of his position with reference to the many phases of physical science. However, the volume contains a great deal which is both stimulating to reflection and demanding of discussion. Evidence of this is to be found, indeed, in the very lively discussions and appreciative reviews which it has excited in the French periodicals. The general position which M. Duhem takes seems to me to be of especial opportuneness and interest in connection with current agitation as to radical empiricism and pragmatism. To his view as to hypotheses, the 'standing' of qualities, the purpose of theory, and the means to attain this, the pragmatist might, perhaps, point with satisfaction at finding a position, sympathetic to his own, yet taken by an active physicist. But for M. Duhem this is methodological pragmatism. With the position which goes farther than this and finds in this pragmatism the implications of an ontological doctrine, one with whose outlines we have all been made familiar recently, doubtless much to their disappointment some of our pragmatists would not find him to be in agreement. Capable, indeed, of reasoning rigorously in the field of mathematical physics, he fails to disclose the discovery of any such implications. Is this omission, or does rigorous thinking desert him here?

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The Psychology of the Simple Arithmetical Processes: A Study of Certain Habits of Attention and Association. CHARLES E. BROWNE. *The American Journal of Psychology,* January, 1906. Pp. 1–37.

The study is provided with a full table of contents. The writer's careful summaries will be of use to readers, who will find the article worth their attention. Nine subjects served in the experiments, which were concerned with two types of procedure in arithmetical process: (1) purely mental from visual cues, (2) written and more complex.

It is found that a specific mental attitude corresponds to each of the four main processes, and this is further differentiated as multipliers or divisors vary in size. This attitude is strengthened by the early steps of the problem.

A few of the results of the adding experiments may be mentioned. The tendency to motor expression is a prominent feature of this as of all the arithmetical processes, and increases with the difficulties met. Each step of the adding psychosis contains three phases: recognition of the result thus far, which becomes motorized; recognition of the digit to be added, visual; and a subconscious associative process. The tendencies to error include mental distraction, fatigue and mental vacuity, and false associations often due to the force of similarity, false substitutions either of method or of result. Another kind of error is the skipping or confusing of tens, as when one forgets whether the sum thus far is, say, 66 or 76, due to the lack of emphasis that the tens receive in motorization. Too fast or too slow a tempo decreases accuracy, the latter because it gives more chance for mind-wandering and strengthening of irrelevant associations. The feeling of accuracy is distinguished from the knowledge that one is right; the former is normally subconscious and seems to consist in the absence of the feeling of error. The adding of even numbers or any factorable series is relatively easy since the associative bond is strong in proportion as it involves primitive links like those of counting. Correlation with Ebbinghaus's memory tests is shown in the law that ease of combining is directly proportional to the difference between the two digits, or inversely to the size of the smaller. 'Counting is purely a verbal formula,' quite as arbitrary as a series of nonsense syllables.

Incipient motorization of results is a relic of one's early practise of counting and of addition tables, and is the root of the feeling of assurance. A similar fact holds of the other arithmetical processes. In many subjects a tendency was discovered for other aspects of the psychical process to run ahead of this motor fixation of the results, bringing danger of confusion or error. This indicates essential limits to the variation of different subjects in their mode of motorizing: in adding, lingual motorization is either gradual and prolonged or inhibited and sudden, the latter involving excess of strain alternating with recovery; in multiplying, if the problem is difficult, manual motorization is gradual, otherwise it follows as a 'detached and automatic part of the process.'

In multiplication, two types of difficulty are discovered: that of carrying and that of adding. According to the author, one cause of the former is as follows: In multiplication, visual are of little importance as compared with motor images. "Here there seems to be a clash of motor images. The motor ten of the foregoing product is to be added to the following motor product." But while in ordinary addition a motor and a visual image may coexist and be readily combined, two simultaneous motor images can not share the attention. This view has some plausibility, but it is possible that the author fails here to distinguish between images and sensations. If two visual or two auditory images can be noted together, there is nothing improbable in a similar coexistence of two motor images. At this point the study also neglects the influence of practise in effecting difficult combinations. Therefore one may hesitate to accept the writer's first pedagogical corollary, *viz.,* to adopt 'the method of writing the entire products at each step' and concluding the process with addition, as a remedy for the above. His other corollaries seem well founded: the need of thorough mastery of the multiplication tables as an instrument and a standard, of simplifying the verbal formula employed therein to guard against fatigue through motorization, and of diminishing the size of the tables *en masse* by one half, because three 9's equal nine 3's.

Subtraction and division are found to be harder than addition and multiplication because of the reverse order of the associative bonds involved; the former are said to be 'far more immediate' than the latter, though 'far *less* practised,'[1] and to be marked by less confidence and by 'proving.' These relations account for the method of 'subtracting by adding,' which in practise, however, gives way to 'immediate association.'[2] The resulting digit is written automatically, perhaps from an unnoticed visual cue, and the act may be either explosive or gradual. Borrowing is attended with difficulties, such as the 'possibility of having to visualize a 4, say, with a perceived 5 directly in the field of vision.' The author gives a detailed analysis of the process, attended with diagrams showing the order of the attentive movement in different methods of subtracting. From this it is concluded that the method of increasing the subtrahend is superior to that of decreasing the minuend, because in the former there intervenes in the mental process, between the borrowing and the returning, a less number of focal points to be disturbed or, conversely, to disturb the memory of borrowing. Details can not be given further here, but the demonstration is excellent.

Purely mental division seems attended by more assurance than subtraction, so that 'verification tends to fall away.' The quotient is often reached by a process of multiplication. Errors commonly consist in substituting a wrong factoral divisor or in the functioning of a mechanical run-on association leading to counting or repeating a digit instead of dividing. Difficulty in dividing varies with the ratio in size between the divisor and partial dividend. The writing of the result tends to become an automatic process running parallel to the mental process. This automatic movement is more efficient when evenly sustained than when consisting in the sudden writing of a digit after the mental result is assured, for the latter makes a break in the mental process, and is more fatiguing.

The author organizes his facts well from the point of view of the topics indicated in the title of the article. He dwells on the interrelation of the four processes, and studies fully the usual types of error. With the prominence of the distinction between true and false, between valid and invalid processes, his point of view is in part that of functional psychology. The idea of control under the dominance of mathematical purpose is plainly implied, but the study of purpose itself and of the logical significance of these processes as a whole or in their elements was beyond the scope of the article. It is not a far step, however, to the recognition of the conceptual value of the number images, whether motor, auditory or visual, and of the instrumental value, subsidiary to arithmetical thinking, of the more automatic processes. Even these simple arithmetical processes involve concepts and judgments, they are not mere mechanical associations. Every exercise in the experiments described was an attempt by the subject to solve a problem within this thought field. While the names of numbers may be arbitrary, even counting, when it is real counting and aroused by a genuine stimulus, is organic rather than mechanical. Its mechanization is only explained by the need of such a solid basis for the solution of more elaborate problems such as those of simple addition. Addition differs from counting in being a more highly organized activity having a selective control of habitual associative processes identical with or based upon those of counting. Thus such a psychological study as that reviewed is not far from a logical study whose aim is to point out the nature of erroneous processes, their conditions, and how to avoid them. The article expresses its affiliation with pedagogy, and this also shows the natural interlacing of the normative and the descriptive points of view.

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[1] P. 23. Italics mine.

[2] P. 30. The immediate is then decidedly the result of mediation and practise.

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JOURNALS AND NEW BOOKS

ZEITSCHRIFT FÜR PSYCHOLOGIE UND PHYSIOLOGIE DER SINNESORGANE. March, 1906, Band 41, Heft 2 u. 3. Abteilung für Psychologie. *Untersuchungen über psychische Hemmung* (Schluss): G. HEYMANS. – In visual contrast with a constant relation between background and field the latter was reduced in brightness, which reduction was independent of the absolute light intensity; or, in the language of the inhibition theory, for intensive contrast as well as for suppression previously established, the coefficient of inhibition is constant. The results when the relation was varied to the point of suppression lead to the view that positive contrast, negative contrast and suppression are not different facts but merely exemplifications of varying degrees of inhibition. Theoretical observations on the distribution of mental energy follow. *Merkfähigkeit, Gedächtnis und Association* (Schluss): KURT GOLDSTEIN. – Experiments on memory in the feeble-minded. Results show that it is necessary to distinguish memory proper and capacity of observation. Impression (*Einprägung*) and capacity of associative observation common to both; memory proper depends more on the latter. Imbecility is characterized by lack of associative observation; acquired feeble-mindedness by lack of capacity for impression. In acquired feeble-